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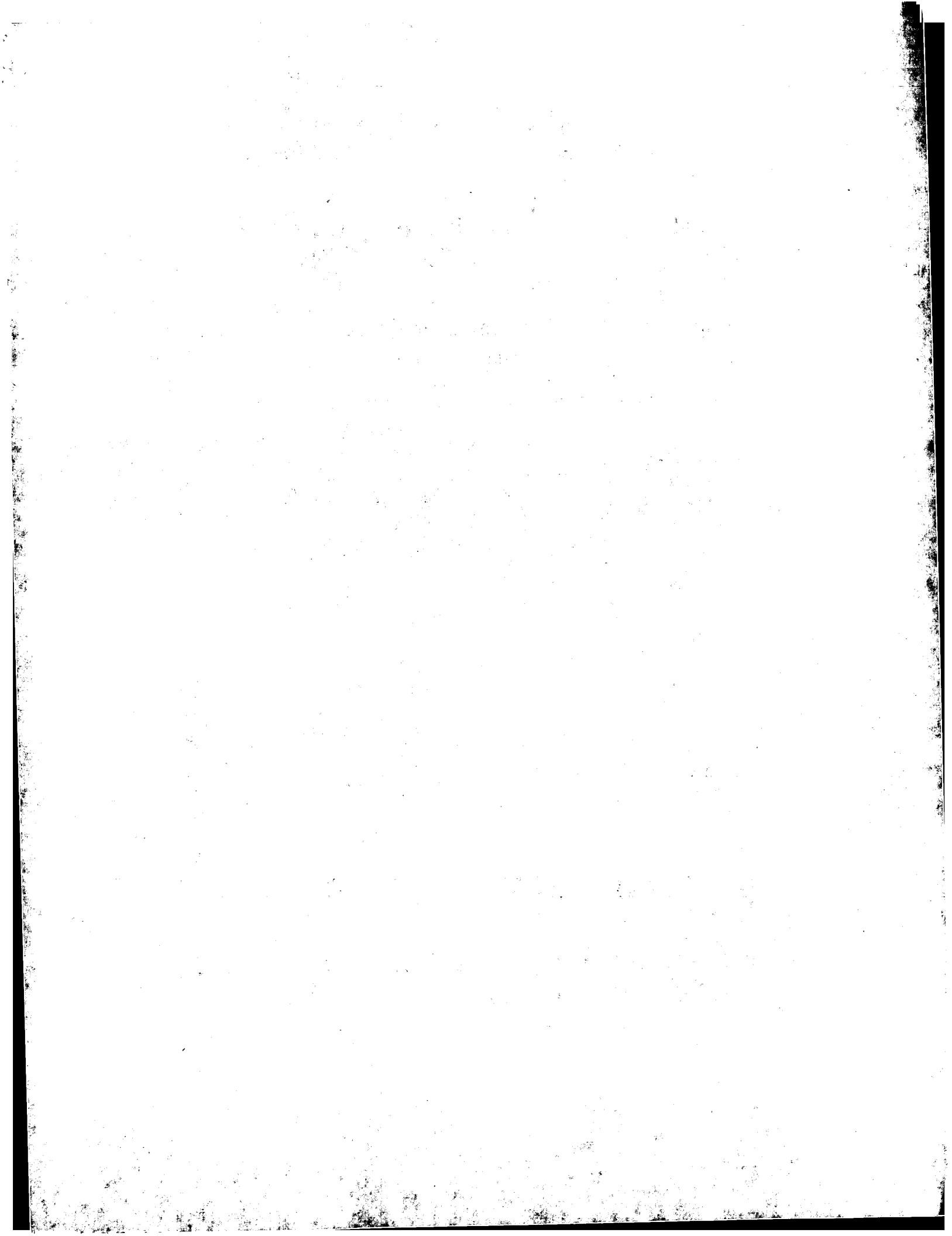
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Dated 2 October 2003



Request for grant of a patent



1/77

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Cardiff Road
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1. Your reference 03 42050

2. Patent application number 23 SEP 2002 0222067.1

3. Full name, address and post code of the or each applicant
Mitel Knowledge Corporation
350 Legget Drive
P.O. Box 13089, Kanata,
Ontario, Canada K2K 2W7

Patents ADP number 08090557001

If the applicant is a corporate body, give the country/state of its incorporation
A company organised and existing under the laws of the Province of Ontario

4. Title of the invention ASYMMETRICAL LOUDSPEAKER ENCLOSURES WITH ENHANCED LOW FREQUENCY RESPONSE

5. Name of your agent VENNER, SHIPLEY & CO

"Address for service" in the United Kingdom to which all correspondence should be sent
20 LITTLE BRITAIN
LONDON
EC1A 7DH

Patents ADP 1669004

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or each of these earlier applications and the or each application number

Country

Priority application number

Date of filing

7. If this application is divided or otherwise derived from an earlier UK application, give the number and filing date of the earlier application

Number of earlier application

Date of Filing

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Patents Form 1/77

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Description 5

Claim(s) 1

Abstract 1

Drawing(s) 4

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Priority documents N/A

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Statement of inventorship and right to grant of a patent (*Patents Form 7/77*) 1

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I/We request the grant of a patent on the basis of this application.

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Date

23 September 2002



12. Name and daytime telephone number of person to contact in the United Kingdom

MATTHEW READ
020 7600 4212

Asymmetrical Loudspeaker Enclosures with Enhanced Low Frequency Response

Field of the Invention

5

The present invention relates generally to loudspeaker enclosures, and more specifically to a speaker system having two loudspeaker enclosures to achieve enhanced low frequency response.

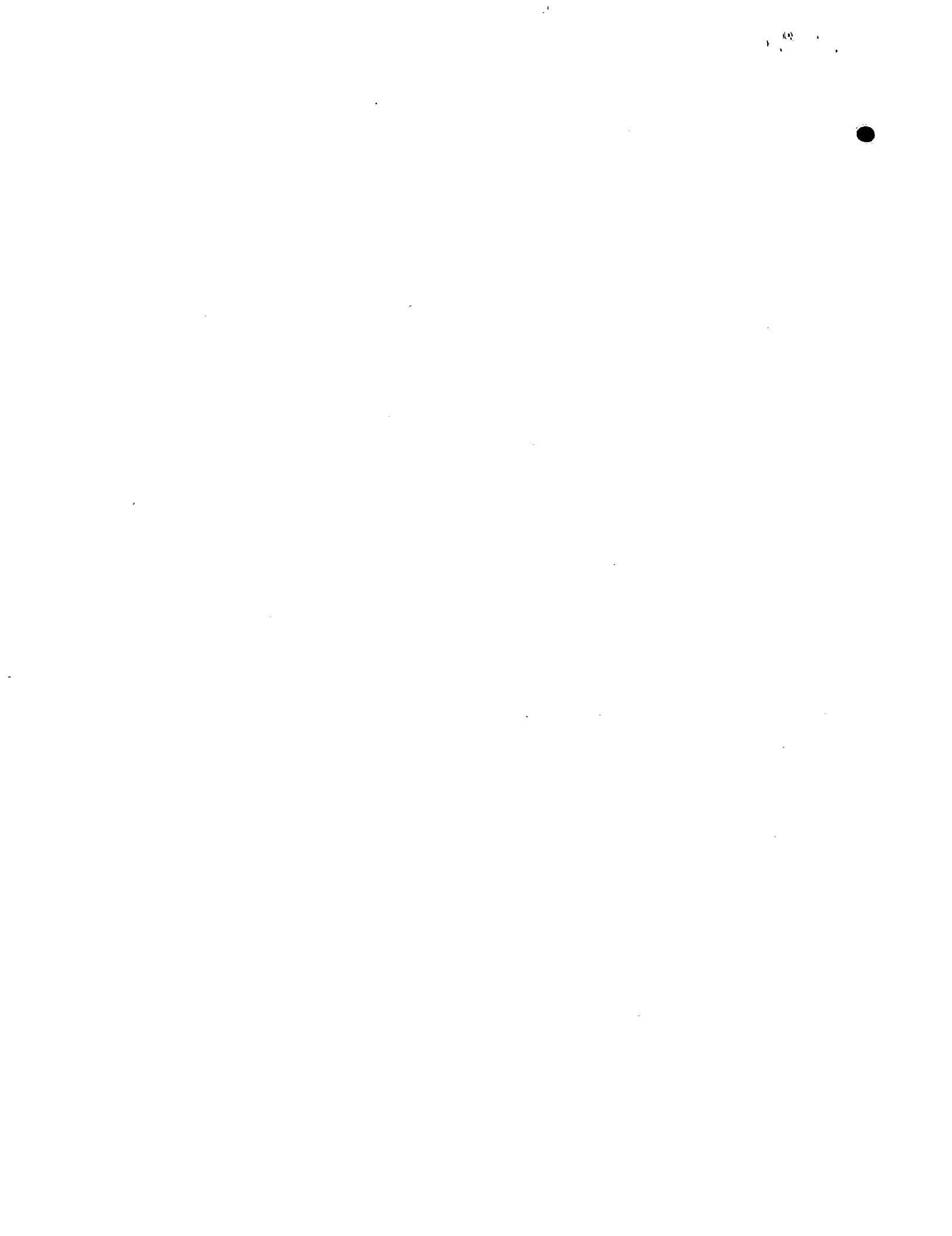
10 **Background of the Invention**

In a telephone set, cost considerations dictate the quality and size of speakers used. Typical 50 mm to 66 mm diameter telephone speakers have a first resonance frequency from about 220 to 350 Hz whereas smaller speakers can have a 15 first resonant frequency close to 500 Hz. When the speakers are enclosed in a sealed box, these frequencies shift up consistently, such that it can be difficult to meet specifications for wide band telephony hands free operation (150Hz-7kHz).

The conventional method for increasing low frequency response is to 20 use a bass-reflex design. Small speaker enclosures give rise to the problem of vortex noise for which a number of solutions have been proposed, such as those disclosed by Van Schyndel in US Pat 5757946, Roozen in US Pat 6275597, and Polk in US Pat 5809154. These solutions all teach the use of a single enclosure to achieve a desired frequency response.

25

Stereo loudspeaker enclosures of various types are omnipresent in audio-visual products either as separate components (e.g. sound systems, personal computers) or embedded within products (e.g. televisions, computer monitors, etc.) In all such cases the two enclosures (left and right) are of identical acoustical response and usually of the same size and shape. In some cases, stereo speakers have the low frequency augmented by the use of a third loudspeaker (sub-woofer) to cover the very low frequency range where humans have difficulty localising the source.



Sound reinforcement systems represents another application in which
multiple enclosures are used. Specifically, different enclosures of different
dimensions may be used for different frequency ranges (e.g. a two-way system
comprising a high frequency cabinet and a low frequency cabinet). In such systems
5 the various cabinets are usually clustered together.

In all of the foregoing systems it is desirable that speaker coverage of a
specific frequency band be accomplished with as flat a frequency response as
possible. Where multiple drivers or enclosures are used, the overlap in frequency
10 response is minimised and is designed so that the transition from one range to another
is as smooth as possible.

Summary of the Invention

15 According to the present invention an embedded loudspeaker system is
set forth incorporating at least two asymmetric enclosures (i.e. different sizes) having
different but overlapping frequency responses in order to achieve a substantially flat
frequency response at the listener position.

20 At least one of the speaker enclosures is preferably ported (bass-reflex
system) to provide as much output as possible in the low-frequency range. By using a
plurality of speakers at least one of which has a bass reflex enclosure, a monophonic
system is provided with a flat frequency response. The dimensions of the speaker
enclosures are chosen such that the anti-resonance of one loudspeaker enclosure is
25 compensated for by the resonance of another speaker enclosure, without making use
of damping, so that no "notch" appears in the frequency response of the combined
system at the listening position.

Brief Description Of The Drawings

30

A detailed description of the preferred embodiment is set forth herein
below having regards to the following drawings, in which:

Figure 1 is the frequency response of a single speaker on the left corner of a typical telephone set.

5 Figure 2 shows the telephone set measurement that gives rise to the response of Figure 1.

Figure 3 is an exploded view of the assembly of the speaker enclosure for the telephone set measurement of Figure 2.

10 Figure 4 is the frequency response of a 60cc speaker enclosure in accordance with the preferred embodiment.

Figure 5 is the frequency response of a 25cc speaker enclosure in accordance with the preferred embodiment.

15 Figure 6 is the frequency response for a combination of both the 60cc speaker and 25cc speaker in accordance with the preferred embodiment.

20 Figure 7 is the frequency response of Figure 6 shown in 1/3rd octave bands fitting within proposed TIA wide band requirements.

Detailed Description Of The Preferred Embodiment

25 Figure 1 shows the frequency response of a small speaker having a first resonance frequency in free field of about 410 Hz, mounted in an optimised ported box at the left corner of a telephone set, according to the test set-up of Figure 2. Specifically, the response is measured in an anechoic chamber in accordance to ITU-T p.340 at the ERP (Ear Reference Point, 50 cm from the centre of the set)

30 It will be noted from Figure 1 that two resonance peaks appear in the low frequency end, resulting from the port/box resonance (coupled with the speaker diaphragm) and the speaker diaphragm resonance (coupled with the open box), respectively. Two identical (i.e. symmetric) speakers would result in the same frequency response increased by 6 dB.

Figure 3 illustrates the construction of a ported loudspeaker enclosure such as incorporated into the telephone set of Figure 2. A front cover [1] is provided with an opening to accommodate a separate acoustically transparent decorative grill [2]. A loudspeaker enclosure gasket [3] secures the grill in place, supports the loudspeaker [4], and ensures an airtight seal. The loudspeaker used is a small substantially flat device. Finally, a rear cover [5] of the set provides the mechanical force necessary to maintain an airtight seal about the loudspeaker enclosure and defines the enclosure volume. A bass-reflex port [6] is moulded as an integral part of the rear cover.

As shown in figure 1, the bass-reflex system is tuned at $f_{br}=240$ Hz and the first diaphragm resonance, coupled with the ported enclosure, is about $f_{0br}=550$ Hz (up from $f_0=410$ Hz in free field). If the system is too demanding for the diaphragm efficiency (i.e. if f_{br} is chosen too low compared to the initial f_0) the diaphragm may be incapable of providing enough vibration energy at f_{br} to compress the box air volume and drive the port resonance. This also results in a strong anti-resonance, appearing in the frequency response of Figure 1 close to 1100 Hz.

According to the present invention, in order to prevent strong amplitude variations two loudspeaker enclosures with different volumes and characteristics are used, rather than two identical speakers. This allows for a different tuning of the left and right speaker as shown in Figures 4 and 5. The first enclosure has a volume of 60cc with substantially the same characteristics mentioned previously and its response is shown in Figure 4. The second enclosure has a volume of 25 cc and is tuned so that its coupled loudspeaker diaphragm first resonance frequency is close to the first anti-resonance of the first loudspeaker enclosure. The smaller enclosure response is shown in Figure 5. Figure 6 shows the response of the system with both enclosures when measured according to ITU-T P.340 standard (i.e. the set-up is illustrated in Figure 2).

The combination of asymmetric speaker enclosures enhances the low frequency end of the response curve, generates two diaphragm resonance peaks and prevents the strong anti-resonance amplitude drop evident from Figure 1. Compared

with one or two identical ported speakers, the system of this invention improves amplitude variations at low and medium frequencies. Additionally, the speaker system of the present invention meets the TIA/EIA PN-4705 Draft 7 (expected to be published as TIA-920-200X) wide band audio hands free receive frequency response requirement (1/3rd octave bands), as shown in Figure 7.

Modifications and alternatives of the invention are possible. As can be appreciated, the stereo experience with the asymmetrical system of the present invention is somewhat unusual. In order to provide adequate stereo imaging, signal processing may be used to present the low frequencies to both loudspeakers while separating only the high frequencies. Since humans have fairly poor localisation in lower frequencies the proposed signal processing provides a reasonable quality stereo image. In telephony applications where the primary audio source is monophonic voice with the occasional requirement for stereophonic material (e.g. music on hold) this is an acceptable compromise where space and expense are limited. All such modifications and variations are believed to be within the sphere and scope of the invention as defined by the claims appended hereto.

We Claim:

1. A speaker system comprising:

5

a first loudspeaker enclosure characterised by a first frequency response having an anti-resonance; and

at least one further loudspeaker enclosure that is smaller than said first
10 loudspeaker enclosure and is characterised by a further frequency response having a resonance that overlaps and compensates for said anti-resonance, such that said first and further speaker enclosures provide a flat combined frequency response.

2. The speaker system of claim 1, wherein at least one of said first and further
15 loudspeaker enclosures is ported to provide enhanced low frequency response.

3. The speaker system of claim 1, wherein each of said first and further speaker
enclosure comprises a front cover with an opening, an acoustically transparent grill
20 mounted in said opening, a loudspeaker, a gasket for securing said grill in place and
supporting said loudspeaker, and a rear cover defining an airtight enclosure of
predetermined volume.

4. The speaker system of claim 3, wherein said at least one of said first and
further loudspeaker enclosures further includes a bass-reflex port in said rear cover.
25

5. The speaker system of claim 4, wherein the predetermined volume of said first
loudspeaker enclosure is 60 cc and the predetermined volume of said further
loudspeaker enclosure is 25 cc.

30 6. The speaker system of any one of claims 1 to 5, further including a digital
signal processor for separating high frequency portions of said first and further
frequency responses in order to provide stereo audio.

ABSTRACT

An embedded loudspeaker system is set forth incorporating at least two asymmetric enclosures having different but overlapping frequency responses in order 5 to achieve a substantially flat frequency response. At least one of the speaker enclosures is preferably ported (bass-reflex system) to provide as much output as possible in the low-frequency range. By using a plurality of speakers at least one of which has a bass reflex enclosure, a monophonic system is provided with a flat frequency response. The dimensions of the speaker enclosures are chosen such that 10 the anti-resonance of one loudspeaker enclosure is compensated for by the resonance of another speaker enclosure, without making use of damping, so that no "notch" appears in the frequency response of the combined system at the listening position.

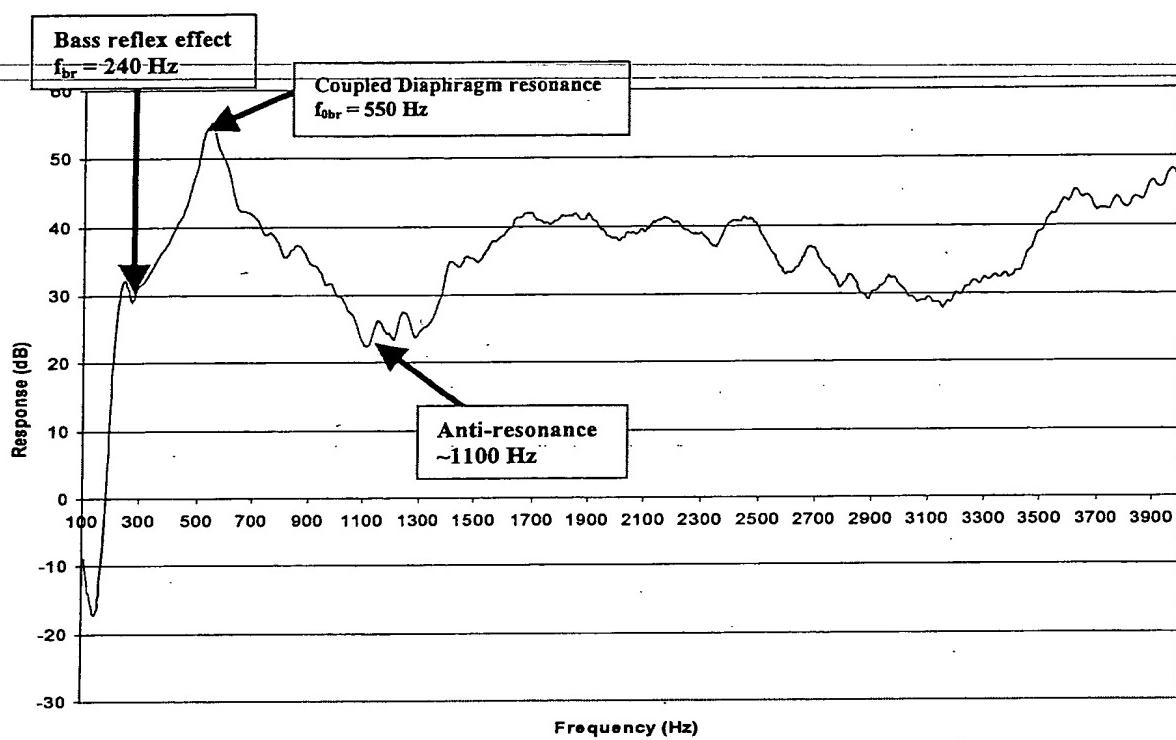


Figure 1

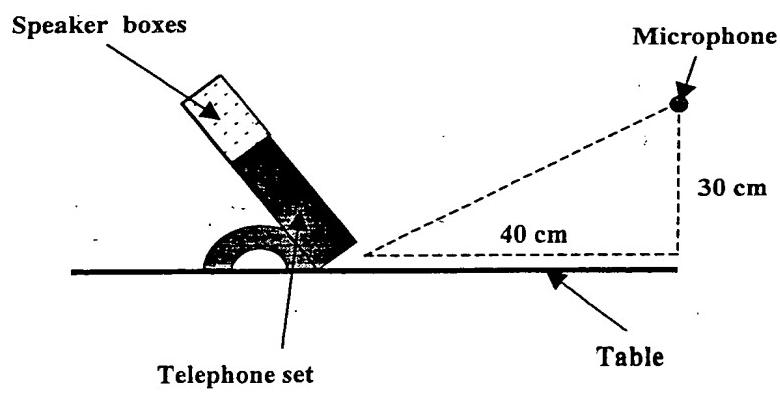
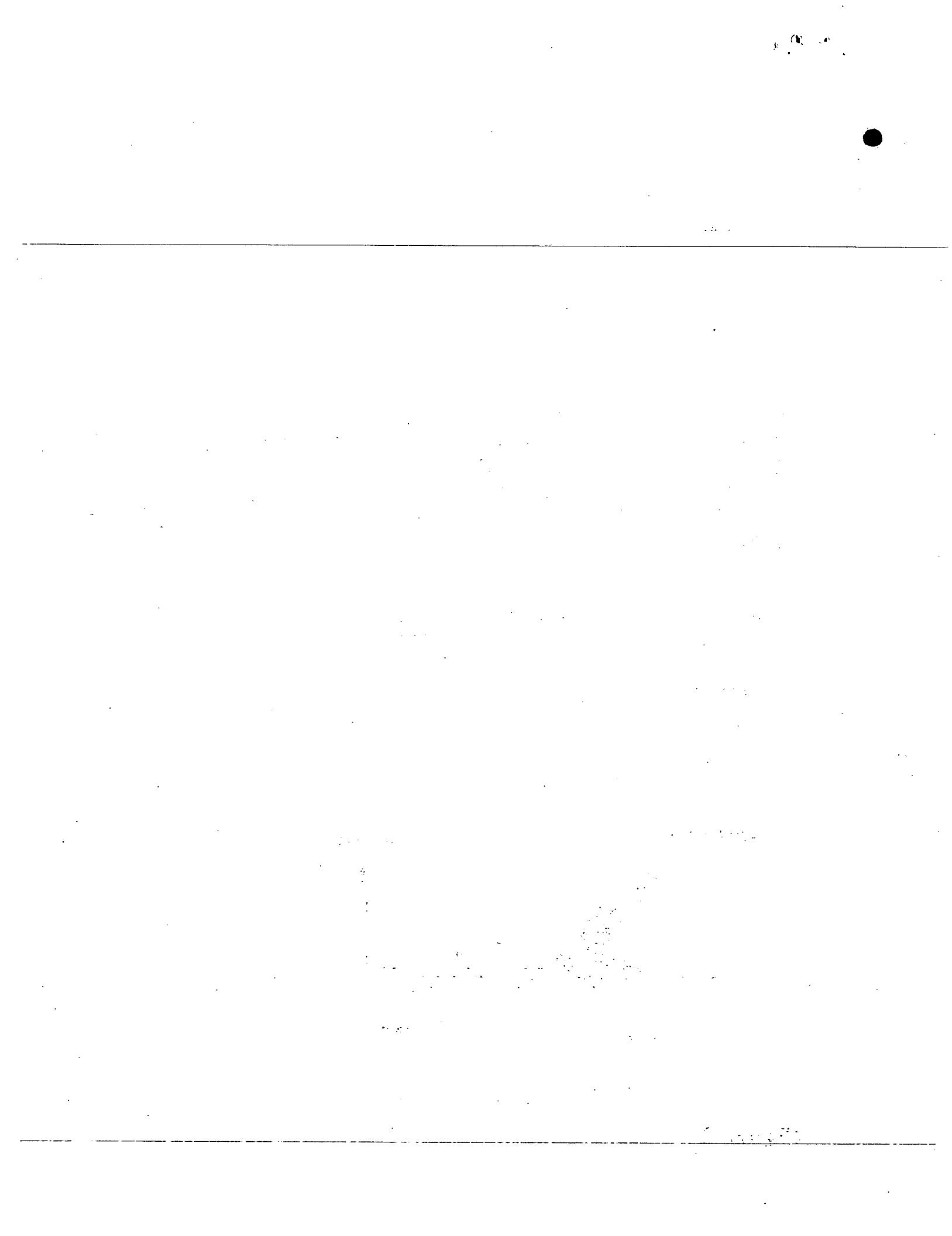


Figure 2



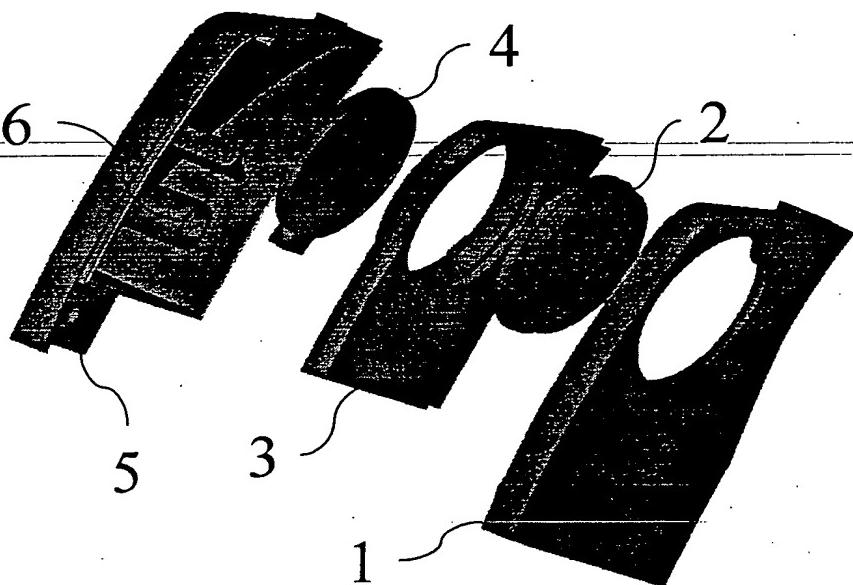


Figure 3

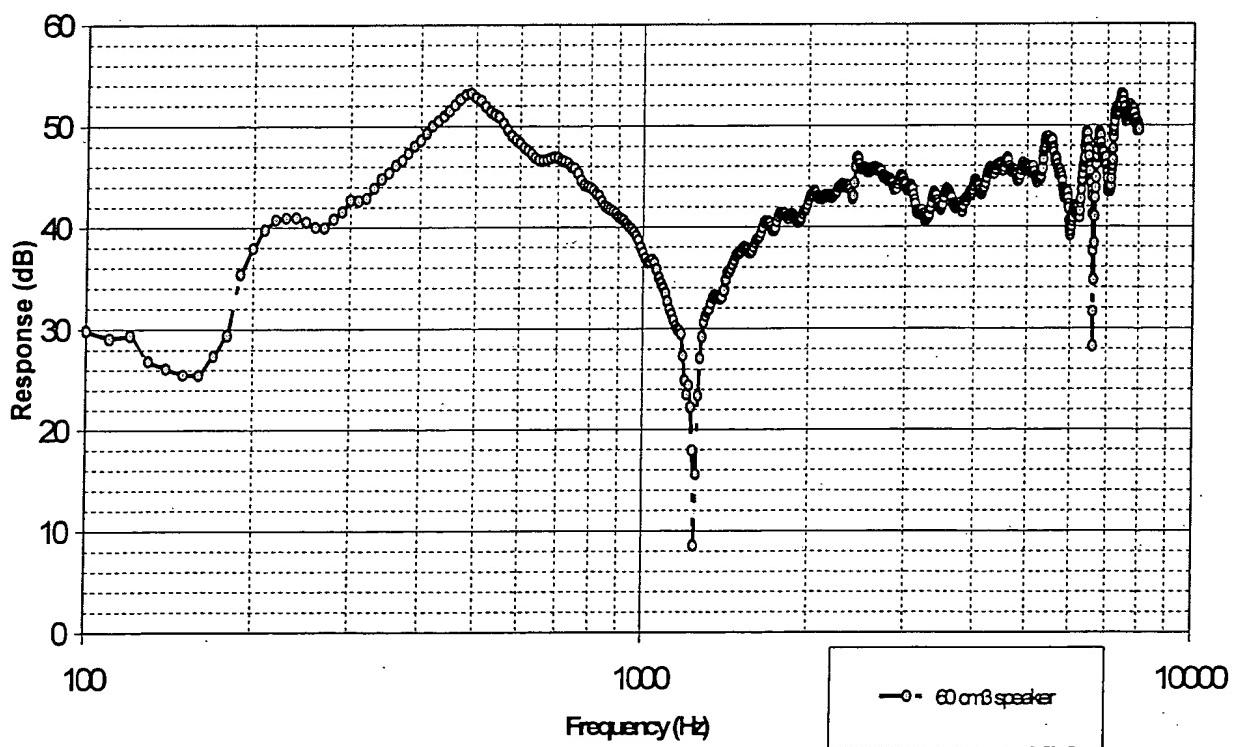
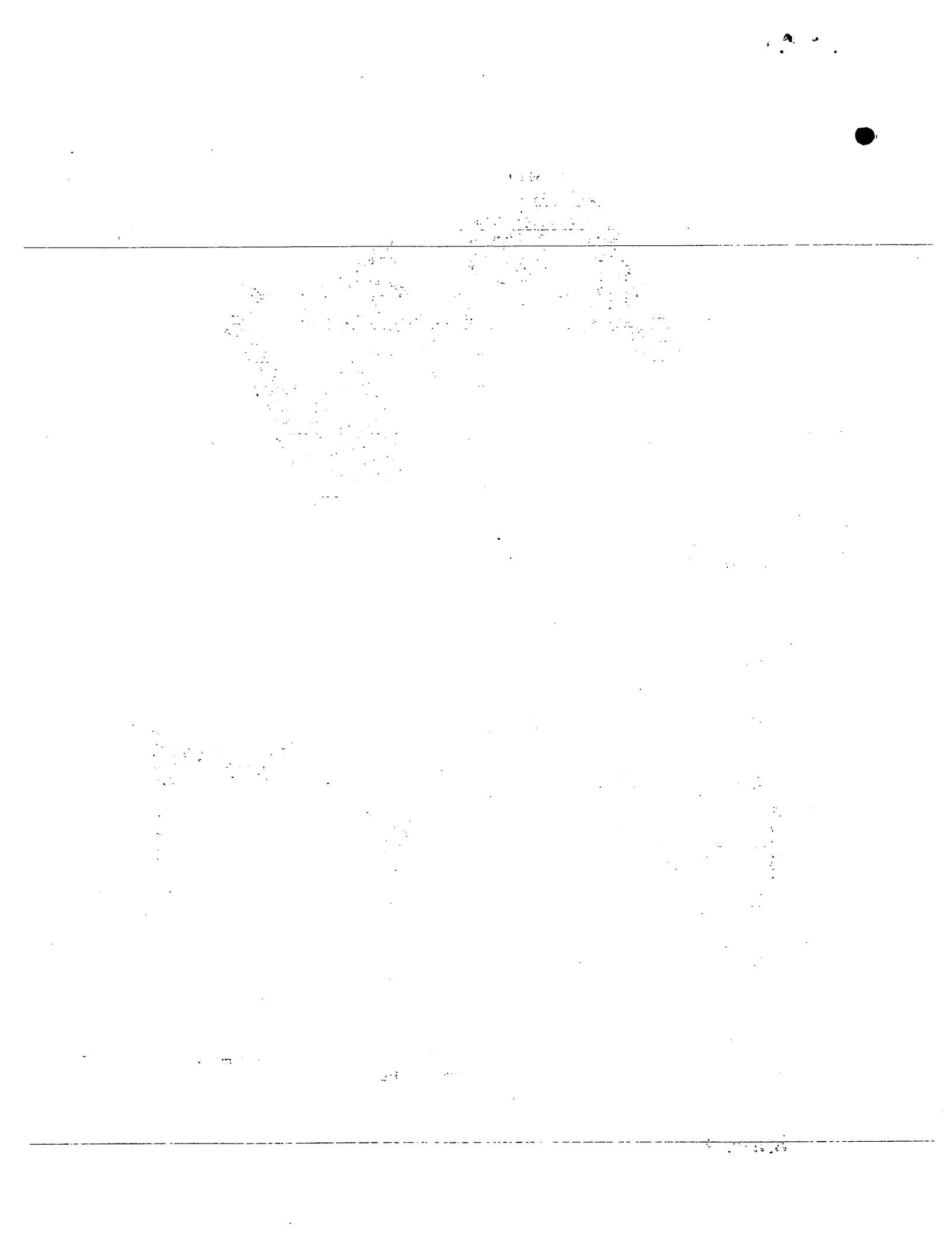


Figure 4



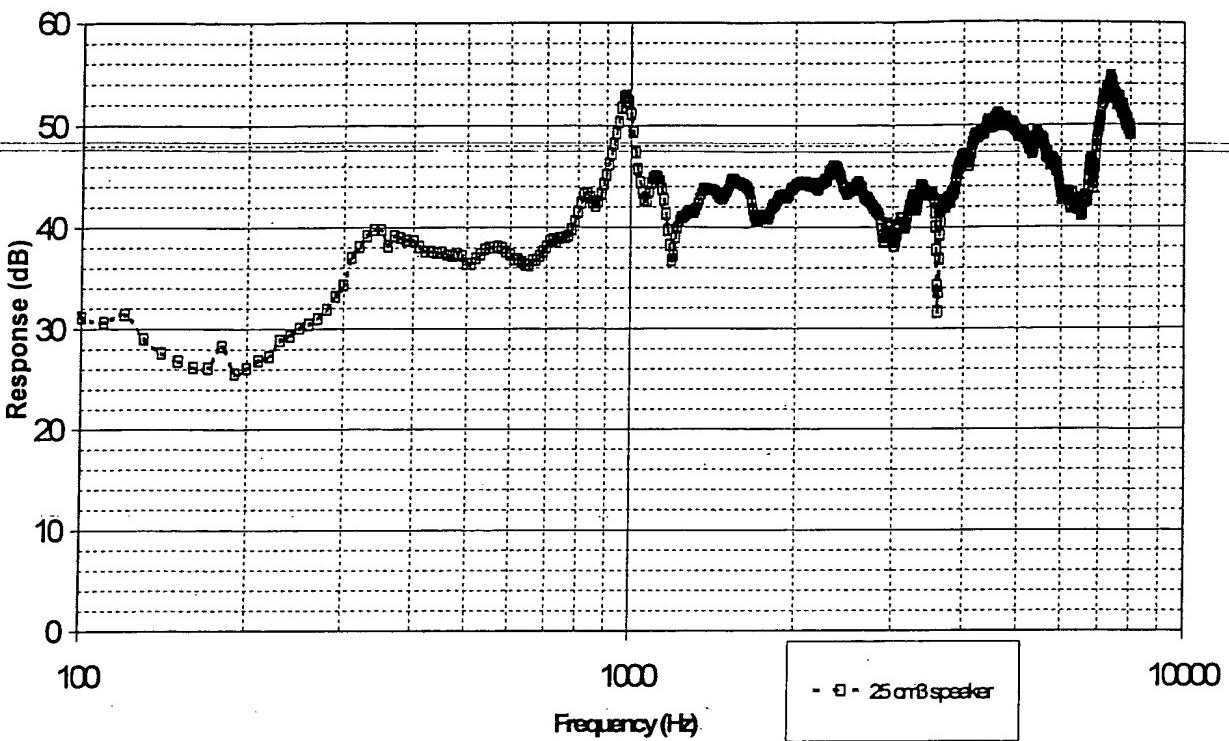


Figure 5

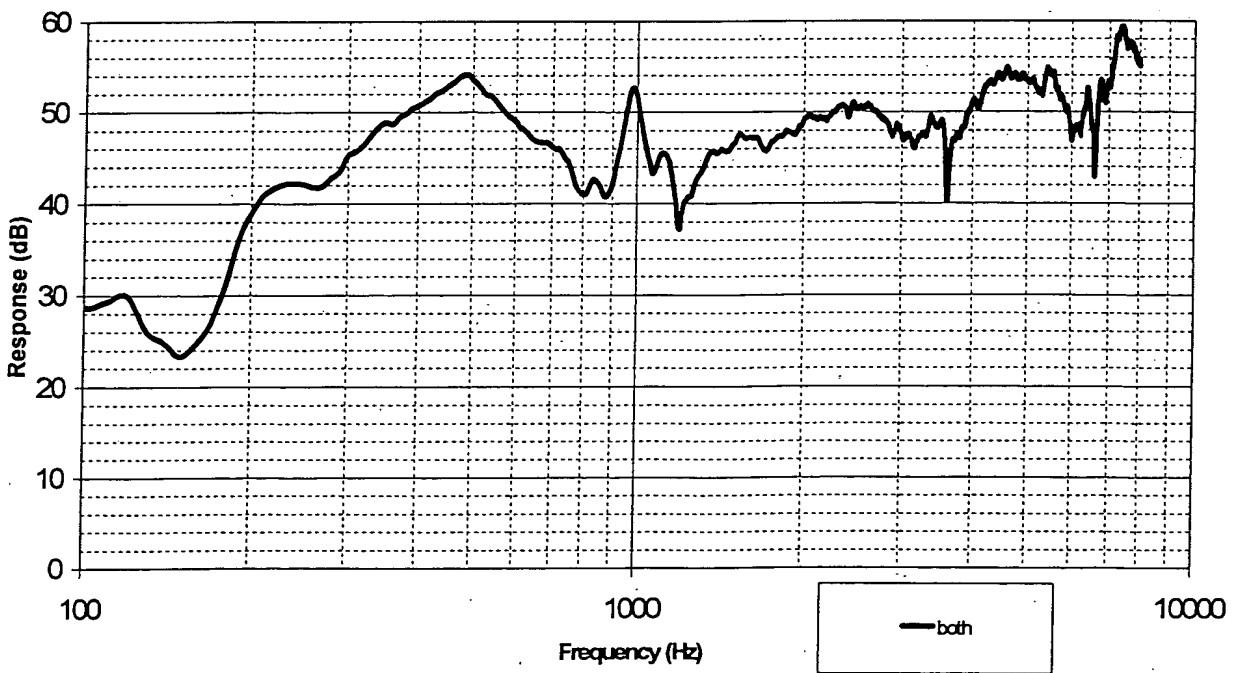
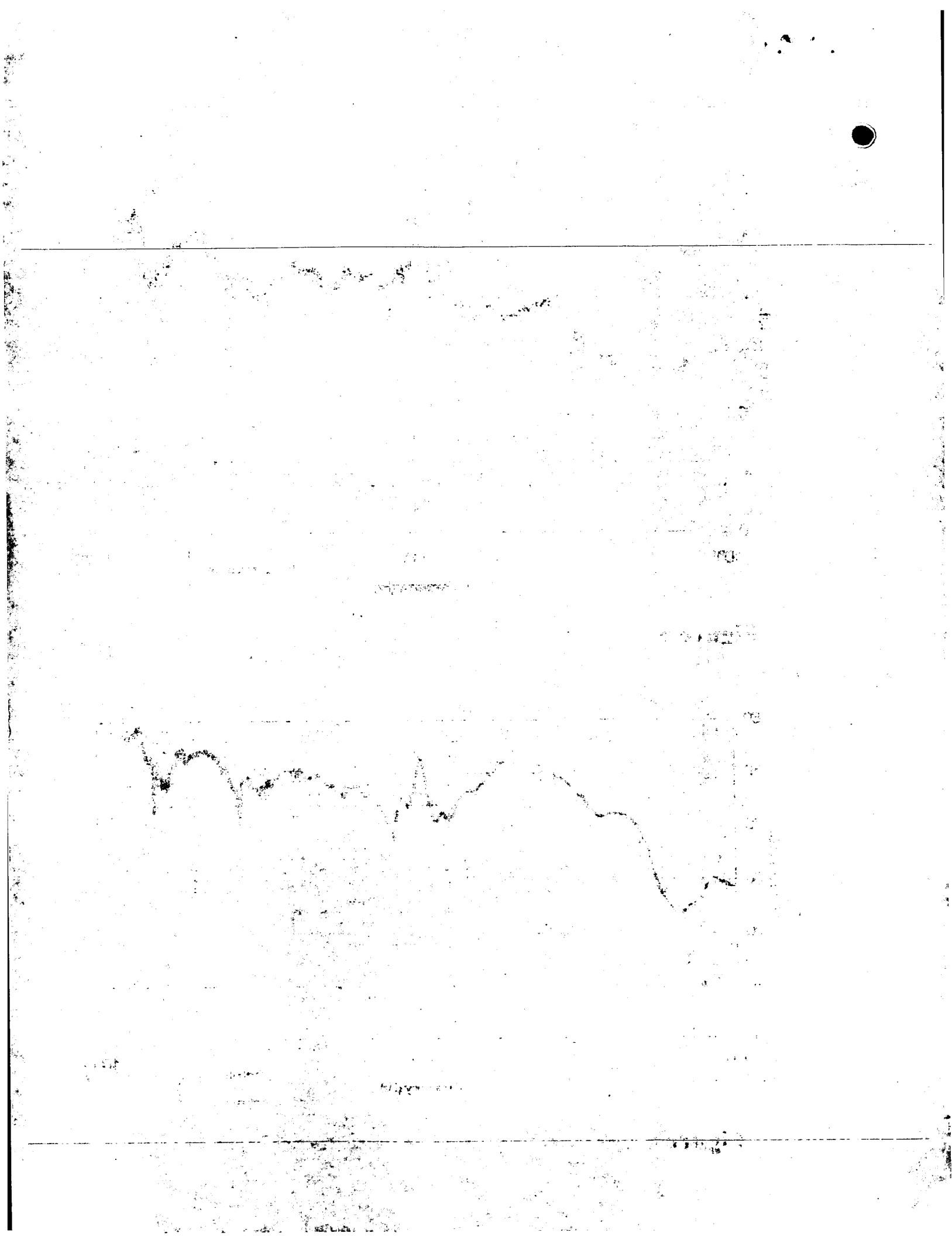


Figure 6



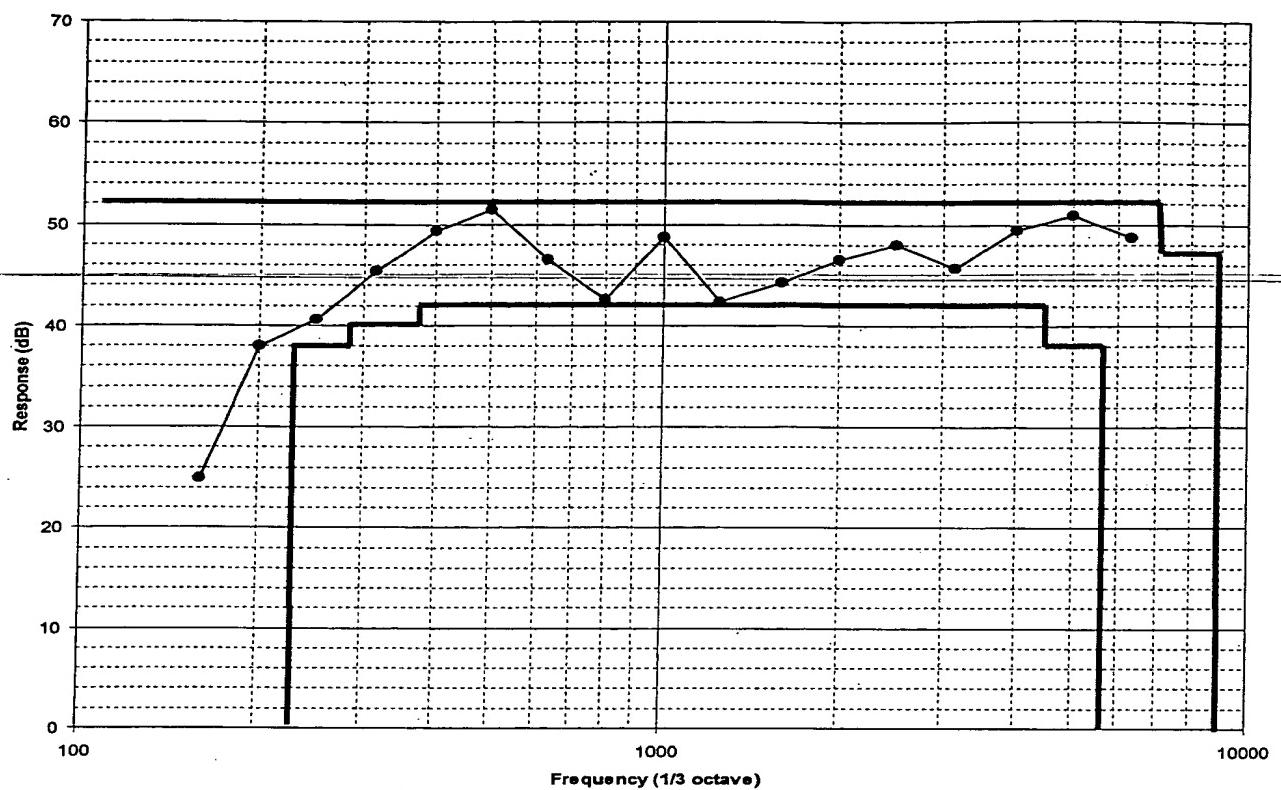


Figure 7

